NASA Contractor Report 3417

Cumulative Annoyance Due to Multiple Aircraft Flyovers With Differing Peak Noise Levels

Kevin P. Shepherd

CONTRACT NAS1-14970
MAY 1981

NASA

NASA Contractor Report 3417

Cumulative Annoyance Due to Multiple Aircraft Flyovers With Differing Peak Noise Levels

Kevin P. Shepherd
The Bionetics Corporation
Hampton, Virginia

Prepared for
Langley Research Center
under Contract NAS1-14970

National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1981

I

BlANK PAGE

SUMMARY

A laboratory study was conducted in which 160 subjects judged the annoyance of 30-minute sessions of aircraft noise. Each session contained nine flyovers consisting of various combinations of three takeoff recordings of a Boeing 727. The subjects were asked to judge their annoyance in the simulated living room environment of the laboratory and also to assess how annoyed they would be if they heard the noise in their home during the day, evening, and night periods.

The standard deviation of the sound level did not improve the predictive ability of L_{eq} (equivalent continuous sound level) which performed as well or better than other noise measures. Differences were found between the projected home responses for the day, evening, and nighttime periods. Time of day penalties derived from these results showed reasonable agreement with those currently used in community noise indices.

INTRODUCTION

Numerous laboratory experiments have been conducted to examine the effects of various acoustical parameters on the annoyance due to individual aircraft flyover sounds. More recently these laboratory techniques have been used to measure the annoyance due to multiple aircraft sounds (1 - 4) in an attempt to provide a more realistic simulation of aircraft noise in a community. Most previous investigations of community noise using social survey techniques have shown a marked inability to provide a precise description of the relationship between annoyance and the physical characteristics of the noise environment. In part, this has been due to errors in the quantification of the noise and it was therefore anticipated that the careful control of variables made possible in a laboratory would produce results to supplement those found in field studies.

Several laboratory studies have investigated the trading relationship between aircraft noise level and the number of events (1 - 3). This paper describes a study in which the number of flyovers in a session was held constant and the peak noise levels of the flyovers were systematically varied. Several hypotheses concerning the integration of annoyance of multiple aircraft events are compared.

SYMBOLS AND ABBREVIATIONS

SSV	subjective scale value
dB(A)	A-weighted sound pressure level
L_{eq}	equivalent continuous sound level in dB(A)
PNLT	tone corrected perceived noise level
EPNL	effective perceived noise level
L_{DN}	day-night level
L_x	dB(A) level exceeded "x" percent of time period
σ	standard deviation of the instantaneous A-weighted sound pressure level
r	Product moment correlation coefficient.

EXPERIMENTAL METHOD

Test Facility

The Interior Effects Room of the NASA Langley Aircraft Noise Reduction Laboratory was used in the present experiment. This room is furnished as a living room (Fig. 1) and its construction is typical of modern single-family dwellings. Four loudspeakers are mounted above the corners of the ceiling to provide a realistic simulation of residential aircraft noise. This test facility was carefully designed to give uniform sound levels across seat locations and to have sound transmission qualities typical of residential structures. Further details may be found in reference 5.

Noise Stimuli

Each 30-minute test session contained nine flyovers consisting of various combinations of three Boeing 727 take-off recordings made between 4.5 and 8 Km from brake release. The time histories and peak level spectra recorded in the test room are presented in Figures 2 and 3. The peak noise levels were approximately equal to the indoor levels that would have been produced in a residential structure at the recording position. The test stimuli were therefore considered to be realistic in terms of their spectra, durations and peak levels. The sounds were presented by means of a tape recorder and a computer which controlled the timing, the sequence, and attenuation required by the experimental design.

A total of 10 sessions, each containing 9 flyover sounds, were used in the experiment. Table I details the content of these sessions which have a range of L_{eq} of 22 dB(A).

Experimental Design

The nine sounds in each session (Table I) were presented in a random sequence at 3-minute intervals plus or minus a random number of seconds between 0 and 45. This interval between flyovers is approximately equivalent to that occurring in a busy airport community. The order of presentation of sessions to subject groups was determined by a counter balanced design (Table II) since this factor was shown to be important in a previous study (1).

Each subject group was exposed to experimental session number three (Table I), so that at a later stage it would be possible to quantify the effect of the confounding of subject groups and test conditions inherent in the design. This confounding was the result of the impracticability of each subject judging all experimental conditions.

Examination of the annoyance judgments of session number three yielded no significant differences between the three sets of subject groups (Table II). This result implies that the subjects were indeed randomly assigned to groups and that the differences between the sets of sessions composing a test did not influence the annoyance judgments. As a consequence, further subjective data were collected in a more efficient manner. The order of presentation of sessions to the remaining subject groups is given in Table III.

Test Subjects

One hundred and sixty subjects were randomly selected from a demographically representative pool of local residents. These paid volunteers who were audiometrically screened, were randomly divided into 32 groups of 5 subjects each. Approximately one-half had previous experience in judging aircraft noise.

Procedure

Upon arrival at the laboratory each subject was given a consent form, an instruction sheet, and a scoring sheet. After reading the instructions and completing the consent form, the subjects were given an opportunity to ask questions and then escorted to the test facility where they were randomly assigned to their seats. During the testing period the subjects were engaged in reading, needlepoint, etc. They were specifically discouraged from talking.

At the end of each 30-minute session, the test conductor returned to the facility, collected the completed score sheets and issued new ones. The subjects assessed their annoyance in the laboratory using a 0 to 10 numerical category scale with the ends of the scale labeled "not annoying at all" and "extremely annoying". They also assessed how annoying the noise would be in their homes during the day, evening and night. A fifteen minute rest break was given halfway through the testing period. Copies of the instructions and score sheets are presented in Appendicies A and B and a post-test questionaire is in Appendix C.

RESULTS AND DISCUSSION

Analysis of Variance

The subjective data for laboratory annoyance and the three questions concerning projected home annoyance were examined using analysis of variance for the

designs of Tables II and III. A representative result for laboratory annoyance is given in Table IV. In contrast to results reported by Rice (1), the order of presentation of sessions was not found to be a significant factor in any of the analyses. In every case, however, significant differences were found between sessions.

The only important difference between the results of the analyses of the four annoyance questions was a clear tendency for the between-subject variance and error variance to be greater for the projected evening and night annoyance judgments

Regression Analysis

Comparison of annoyance questions. - For each noise exposure condition, various noise measures were calculated including peak dB(A), peak PNLT, EPNL, L_{eq} and the standard deviation of the 'A'-weighted instantaneous sound pressure level. Values of these measures are presented in Table V for each test session. Their relationship with the arithmetic mean of the annoyance judgments was examined using regression analysis, the results of which are presented in Table VI and Figure 4. None of the correlation coefficients of Table VI are significantly different from one another except those for L_5 and, as expected, the correlation between the various measures is extremely high. It proved impossible to discriminate between the peak dB(A) concept advanced by Rylander (6) and the equal energy hypothesis (L_{eq}).

In order to form a measure similar to the Noise Pollution Level (7), the standard deviation of the A-weighted sound level was added as an independent variable to the regression equation relating mean annoyance to L_{eq}.

The addition of this variable resulted in no statistical improvement at a 95% confidence level. A similar result was found for the standard deviation of the peak levels of the sounds.

Information regarding the validity of penalties that have been applied to various community noise indices for night and evening events may be found in the home-projected annoyance judgments. Figure 5 presents these mean annoyance values as a function of L_{eq}. The data fall into groups; the laboratory and projected daytime annoyance judgments form one, and the evening and nighttime judgments form another. The difference between these two sets of data is equivalent to approximately 3-4 dB(A) when either a linear or a second order nonlinear curve is fitted. Clearly, this result does not support the 10 dB nighttime penalty that is frequently used in community noise indices.

Sequence of flyovers in a session. - Given that the subjects are required to make annoyance judgments at the end of a series of flyovers, there is clearly the possibility that a less than perfect memory will cause flyovers occurring near the end of a session to be weighted more heavily than those at the beginning. In order to determine if such an effect was present, the experimental data were examined in various ways.

The initial approach was to calculate, for each session, the proportion of acoustical energy contained in the last flyover, the last two flyovers, etc. Each of these statistics was added as an independent variable to the regression equation relating mean annoyance and L_{eq} and in no instance was the addition found to be statistically significant.

The second procedure consisted of calculating L_{eq} values for the last flyover, the last two flyovers, the last three flyovers, etc. in each session. Each of these statistics was added as an independent variable to the regression equation relating mean annoyance and L_{eq} and in no case was the addition found to be statistically significant.

Another approach was to calculate, for each session, the L_{eq} value and ignore the first flyover, the first two flyovers, etc. These revised L_{eq} values provided no improvement over the unmodified L_{eq}.

The final procedure was based on the hypothesis that the annoyance due to the noise of an aircraft flyover decreases with time. Consider, as illustrated in Figure 6, three identical flyovers occurring in an arbitrary time period. The computation of L_{eq} requires that the total acoustical energy be found as shown in Figure 6(b). The hypothesis that annoyance decreases with time, Figure 6(c), is illustrated using an arbitrary linear decay rate which causes an effective reduction of the total acoustical energy. A range of decay rates from 0 to 20 dB per hour were used to calculate new L_{eq} values for each test session. The correlation between these values and the mean of the laboratory annoyance judgments were calculated (Figure 6(d)) and it was concluded that the data did not support a decay hypothesis.

Cumulative Annoyance Over Longer Time Periods. - At the conclusion of the testing period the subjects were asked to assess their annoyance due to all of the aircraft noise that they experienced (Appendix C). These responses could then be examined in terms of their relationship with the noise exposure computed over the entire test period. However, due to the balanced nature of the experimental design, there was essentially no difference in the noise exposure of the various subject groups. For example each group experienced the same peak noise level and the range of values of L_{eq} across subject groups was only 1.2dB.

It was possible, however, to compare the "total test" annoyance scores with those from the individual sessions. The mean annoyance score for the individual sessions was computed for each subject and found to be highly correlated with the "total test" annoyance scores ($r = 0.74$). This result simply reflects

the consistency with which the subjects use the annoyance scale; those subjects giving low scores for the individual sessions also give low annoyance scores for the combined sessions. The "total test" scores were found to be consistently larger than the mean of the individual sessions, indicating that subjects did not simply average their session scores when assessing the total testing period. A more reasonable hypothesis is that the "total test" annoyance scores are related to the total noise exposure expressed as L_{eq}. The mean of the "total test" annoyance scores was found to be not statistically different ($p = 0.05$) from that predicted by the regression line derived from the individual session responses (Figure 4).

The possibility that the sequence of sessions affects the total annoyance judgments was examined. The subjects responses to each session, based on order of presentation, were all highly correlated with their "total test" annoyance scores due to their consistency in using the annoyance scale. There is clearly the possibility that the sounds occurring near the end of the test period are weighted more heavily than those at the beginning when the subjects assess their total annoyance. This hypothesis was tested in the following manner. It can be seen from Table V that sessions 1, 5, 9 and 10 have L_{eq} values that are considerably lower than the other sessions. The subjects' scores were divided into two groups; those who were exposed to sessions 1, 5, 9 or 10 in their last session formed one group and the remainder formed another. There was no statistical difference between the scores of the two groups, thus the hypothesis was rejected.

Percentage of People Highly Annoyed

In an attempt to compare results from community noise surveys which used differing annoyance scales, the statistic "percentage of people highly annoyed" has been utilized (1, 8). After each test session of the present study, the subjects were asked if they were highly annoyed in the laboratory and if they would be highly annoyed by such noise in their homes during the day, evening, and night. (Appendix A)

The percentage of people highly annoyed is presented as a function of L_{eq} (Figure 7) in which the curves are fitted to the data by means of the cumulative normal distribution. Examination of these curves indicates a nighttime penalty of 7-12dB(A) and an evening penalty of 5-7 dB(A) relative to daytime events. These time-of-day corrections are in reasonable agreement with those used in community noise indices. However, these results appear to contradict those derived from the mean annoyance judgments (Figure 5). An explanation is that the standard deviation of the individual judgments are considerably greater for the nighttime and evening annoyance scores, i.e., evening and nighttime annoyance scores tend to be more extreme. When assessing noise in a community, the percent highly annoyed is probably the more apt statistic since the mean annoyance tends to obscure the extreme and, presumably the most serious impact effects. Consequently, the time-of-day corrections derived from the percentage of subjects highly annoyed have been emphasized.

A synthesis of community noise surveys was conducted by Schultz (8) which described a relationship between the percentage of people highly annoyed and L_{DN}. Comparative data from the laboratory were derived from the projected home annoyance judgments by considering a subject to be highly annoyed if he claimed he would be highly annoyed during the day, evening, or night. These results are presented as a function of estimated outdoor L_{eq} in Figure 8 which shows the laboratory judgments to be in reasonable agreement with Schultz' summary of survey data.

CONCLUSIONS

A laboratory study was conducted in which subjects judged the annoyance of sessions of multiple aircraft flyover sounds. Subjects were also required to project their reaction to the noise sessions to their home environment for day, evening, and nighttime periods. The important findings were:

1. There was no evidence that the order of presentation of flyovers within a session had a significant effect on annoyance.

2. The standard deviation of the sound level did not improve the performance of the equivalent continuous sound level (L_{eq}) which was found to be as good or better than other noise measures.

3. There was support for the 10 dB penalty for nighttime events as provided by cumulative noise indices such as L_{DN}. In addition, a penalty of 5-7 dB for evening events is indicated.

4. The order of presentation of sessions was not a significant factor in determining annoyance.

REFERENCES

1. Rice, G. G.: Investigation of the Trade-Off Effects of Aircraft Noise and Number. Journal of Sound and Vibration, 52(3), pp. 325-344, 1977.

2. Borsky, Paul N.: A Comparison of a Laboratory and Field Study of Annoyance and Acceptability of Aircraft Noise Exposures. NASA CR-2772, 1977.

3. Mabry, J. E.; and Sullivan, B. M.: Commercial Airport Operations and Community Noise Criteria. FAA-RD-78-36, 1978.

4. Powell, Clemans A.: Laboratory Study of Annoyance to Combined Airplane and Road-Traffic Noise. NASA TP-1478, 1979.

5. Powell, Clemans A.: Effects of Road-Traffic Background Noise on Judgments of Individual Airplane Noises. NASA TP-1433, 1979.

6. Rylander, R.; Sorenson, S.; and Kajland, A.: Annoyance Reactions from Aircraft Noise Exposure. Journal of Sound and Vibration, 24, pp. 419-464, 1972.

7. Robinson, D. W.: The Concept of Noise Pollution Level. NPL Aero Report Ac 38, 1969, National Physical Laboratory, England.

8. Schultz, Theodore J.: Synthesis of Social Surveys on Noise Annoyance. Journal Acoustical Society of America, 64(2), 1978.

APPENDIX A

INSTRUCTIONS

The experiment in which you are participating today is to help us understand the reactions of people to various aircraft noise environments. There will be four sessions of aircraft noise, each lasting about 30 minutes. At the end of each session, we would like you to make several different judgments on the noises you just heard.

You will be given a scoring sheet for each session which has four scales numbered "0 to 10," the end points of which are labeled "Not Annoying At All" and "Extremely Annoying." An example of these scoring sheets is on the final page of this instruction set. Your judgment in all cases should be indicated by circling one of the numbers on the scale. If you judge the noise to be very annoying then you should circle a number closer to the "Extremely Annoying" end of the scale. Similarly if you judge the noise to be only slightly annoying you should circle a number closer to the "Not Annoying At All" end of the scale.

For the first question and scale, we would like to know how annoying you found the noise of the session. That is, your judgment should reflect your feelings of annoyance in our laboratory situation.

For the next question and the last three scales, we would like you to imagine how you would feel about the noise if you heard it in your home. The first of these last scales is for your judgment of how annoying the noise would be if you heard it during the day, say between 7 a.m. and 7 p.m. The second scale is for your judgment of how annoying the noise would be in the evening, say between 7 p.m. and 11 p.m. The third scale

is for your judgment of how annoying the noise would be at night, say between 11 p.m. and 7 a.m. In making these last three judgments, we would like for you to consider all your home activities during each of the time periods and how you would feel about living with the noise day after day.

Also on each scoring sheet are two additional questions concerning your annoyance to the noises you just heard. On these questions you are to circle either the yes or no response if you were or would be highly annoyed by the noise. That is, whether or not you would consider doing something about the noise, such as, moving or complaining to authorities. The first of these questions is for your feelings in our laboratory situation. The second is for your feelings if you heard the noise in your home during the day, evening or night periods.

There are no correct answers, we just want a measure of your own personal reaction to the noise in each session. For this reason, we request that you do not talk during the tests nor express any emotion which might influence the response of the other people in the room. During each of the sessions, we would like you to relax and read or do any needle work you may have brought with you.

Thank you for helping us with this investigation.

APPENDIX B

SCORING SHEET

Subject No. ____________________ Group ____________________

Seat ____________________ Session ____________________

Code ____________________ Date ____________________

1. How annoying was the noise in the session?

Not Annoying At All 0 1 2 3 4 5 6 7 8 9 10 Extremely Annoying

2. How annoying would the noise be in your home?

(a) During the day

Not Annoying At All 0 1 2 3 4 5 6 7 8 9 10 Extremely Annoying

(b) During the evening

Not Annoying At All 0 1 2 3 4 5 6 7 8 9 10 Extremely Annoying

(c) During the night

Not Annoying At All 0 1 2 3 4 5 6 7 8 9 10 Extremely Annoying

3. Were you highly annoyed by the noise in the session?

Yes No

4. Would you be highly annoyed by the noise in your home?

(a) During the day

Yes No

(b) During the evening

Yes No

(c) During the night

Yes No

APPENDIX C

POST TEST QUESTIONNAIRE

Subject No. ____________ Group ____________

Date ____________________

A. You have heard several different kinds of aircraft noise today. Sometimes the noise was relatively quiet and at other times relatively noisy.

1. Taking all of the aircraft noise together as a whole, how annoying has the noise in the laboratory been today?

(Circle appropriate point on scale)

Not Annoying At All 0 1 2 3 4 5 6 7 8 9 10 Extremely Annoying

TABLE I.- DISTRIBUTIONS OF FLYOVERS WITHIN SESSIONS

Session Number	Number of Flyovers with Peak Levels of		
	56	68	82 dB(A)
1	9	-	-
2	-	6	3
3	3	3	3
4	-	3	6
5	-	9	-
6	6	-	3
7	3	-	6
8	-	-	9
9	6	3	-
10	3	6	-

TABLE II.- ORDER OF SESSION PRESENTATION - PART 1

Subject Group	Session Order			
1	1	2	4	3
2	2	3	1	4
3	3	4	2	1
4	4	1	3	2
5	5	6	7	3
6	6	3	5	7
7	3	7	6	5
8	7	5	3	6
9	8	9	10	3
10	9	3	8	10
11	3	10	9	8
12	10	8	3	9

TABLE III.- ORDER OF SESSION PRESENTATION - PART 2

Subject Group	Session Order				
13	1	2	5	3	4
14	2	3	1	4	5
15	3	4	2	5	1
16	4	5	3	1	2
17	5	1	4	2	3
18	4	3	5	2	1
19	5	4	1	3	2
20	1	5	2	4	3
21	2	1	3	5	4
22	3	2	4	1	5
23	6	7	10	8	9
24	7	8	6	9	10
25	8	9	7	10	6
26	9	10	8	6	7
27	10	6	9	7	8
28	9	8	10	7	6
29	10	9	6	8	7
30	6	10	7	9	8
31	7	6	8	10	9
32	8	7	9	6	10

TABLE IV.- ANALYSIS OF VARIANCE OF LABORATORY ANNOYANCE

JUDGMENTS (SUBJECT GROUPS 13-17)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Subject Groups	141.25	4	35.31	7.59*
Session Order	29.17	4	7.29	1.57
Sessions	242.29	4	60.57	13.02*
Error	520.94	112	4.65	

*Significant at 1 percent level.

TABLE V.- ACOUSTICAL ANALYSIS OF NOISE CONDITIONS

Session	Peak dB(A)*	Av. Pk. dB(A)**	L_{eq}	Av. Pk. PNLT**	Av. EPNL	L_1	L_5	σ
1	56.5	56.5	43.0	65.6	63.8	55.3	50.5	8.47
2	82.0	77.6	60.9	91.9	88.1	74.3	64.0	11.91
3	82.0	77.4	60.5	91.8	87.9	74.3	59.5	10.72
4	82.0	80.3	63.3	94.8	90.8	78.3	66.5	12.80
5	68.5	68.5	54.2	79.8	78.5	67.8	62.0	11.36
6	82.0	77.3	60.1	91.7	87.7	74.3	53.3	9.54
7	82.0	80.2	63.1	94.7	90.7	78.3	63.5	11.89
8	82.0	82.0	64.8	96.5	92.5	80.3	69.8	13.93
9	68.5	64.2	49.8	75.3	74.0	66.3	53.0	9.78
10	68.5	66.9	53.0	78.1	76.8	68.0	58.2	10.73

*Peak dB(A) refers to the highest sound level occurring in a session.
**Av. pk. dB(A) refers to the (logarithmic) average of the peak levels of the flyovers occurring in a session.
L_1, L_5 - dB(A) level exceeded 1 percent and 5 percent of the time period.

TABLE VI.- REGRESSION ANALYSIS OF ANNOYANCE AND NOISE MEASURES

Noise Index	Intercept	Slope	Correlation Coeff.
Laboratory Annoyance			
Average Peak dB(A)	-5.913	0.124	0.947
Peak dB(A)	-5.27	0.111	0.919
L_{eq}	-5.485	0.143	0.940
Average Peak PNLT	-5.590	0.096	0.947
Average EPNL	-6.192	0.107	0.937
L_1	-6.224	0.131	0.914
L_5	-5.366	0.140	0.798
Estimated Outdoor Pk. PNLT	-6.636	0.094	0.951
Estimated Outdoor EPNL	-8.664	0.117	0.891
Projected Daytime Annoyance			
Average Peak dB(A)	-5.951	0.123	0.955
Peak dB(A)	-5.221	0.109	0.916
L_{eq}	-5.556	0.142	0.951
Average Pk. PNLT	-5.607	0.095	0.953
Average EPNL	-6.236	0.106	0.946
L_1	-6.383	0.132	0.934
L_5	-5.763	0.146	0.841
Estimated Outdoor Pk. PNLT	-6.630	0.093	0.955
Estimated Outdoor EPNL	-8.696	0.117	0.953
Projected Evening Annoyance			
Average Peak dB(A)	-7.365	0.152	0.964
Peak dB(A)	-6.455	0.135	0.924
L_{eq}	-6.864	0.176	0.959
Average Peak PNLT	-6.942	0.118	0.962
Average EPNL	-7.715	0.131	0.955
L_1	-7.819	0.162	0.937
L_5	-6.757	0.174	0.818
Estimated Outdoor Pk. PNLT	-8.204	0.114	0.965
Estimated Outdoor EPNL	-10.750	0.144	0.962
Projected Nighttime Annoyance			
Average Peak dB(A)	-6.868	0.145	0.953
Peak dB(A)	-5.928	0.128	0.907
L_{eq}	-6.394	0.168	0.949
Average Peak PNLT	-6.453	0.113	0.950
Average EPNL	-7.187	0.126	0.943
L_1	-7.348	0.155	0.930
L_5	-6.648	0.173	0.839
Estimated Outdoor Pk. PNLT	-7.666	0.109	0.953
Estimated Outdoor EPNL	-10.101	0.138	0.950

Figure 1. - Photograph of test facility.

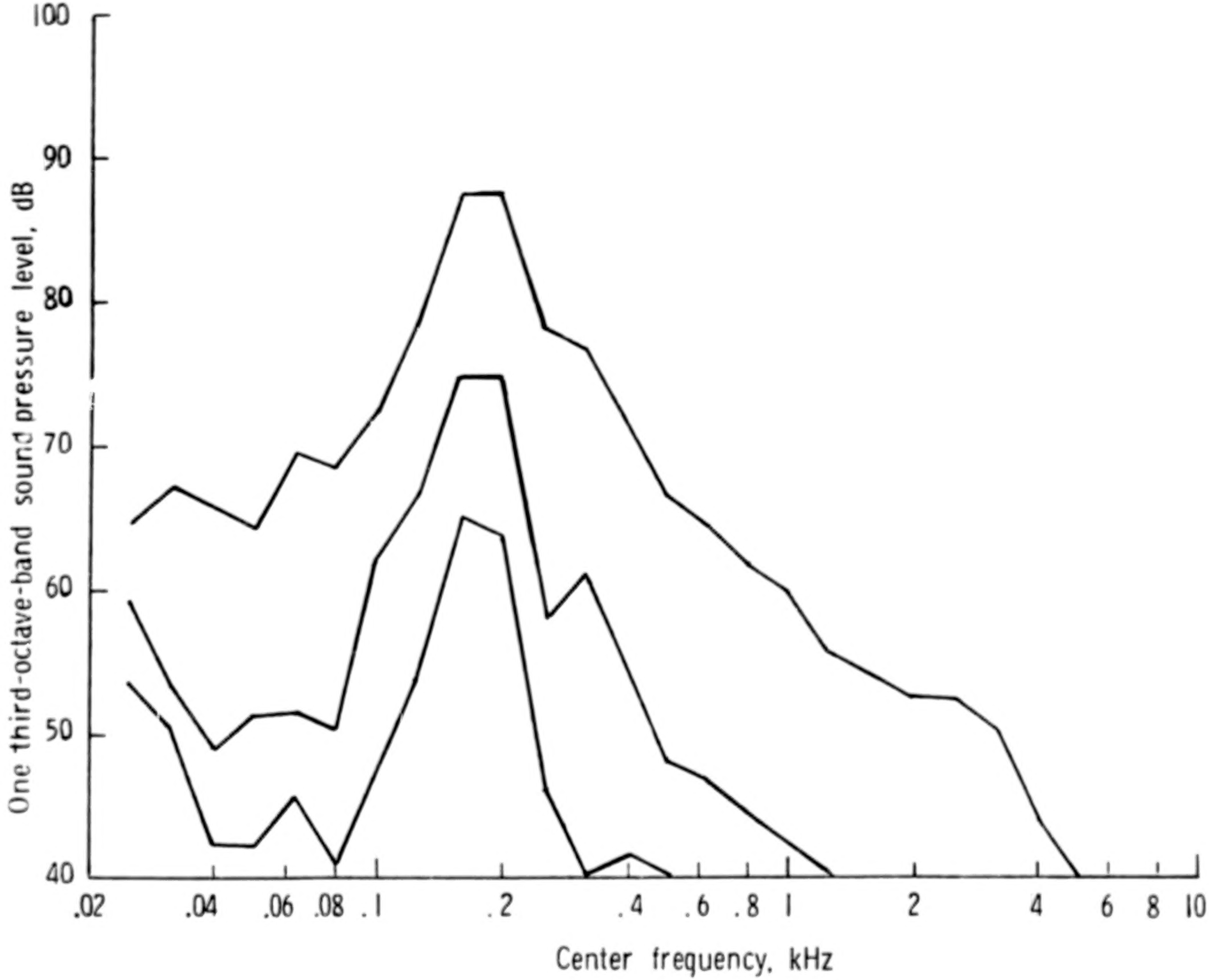
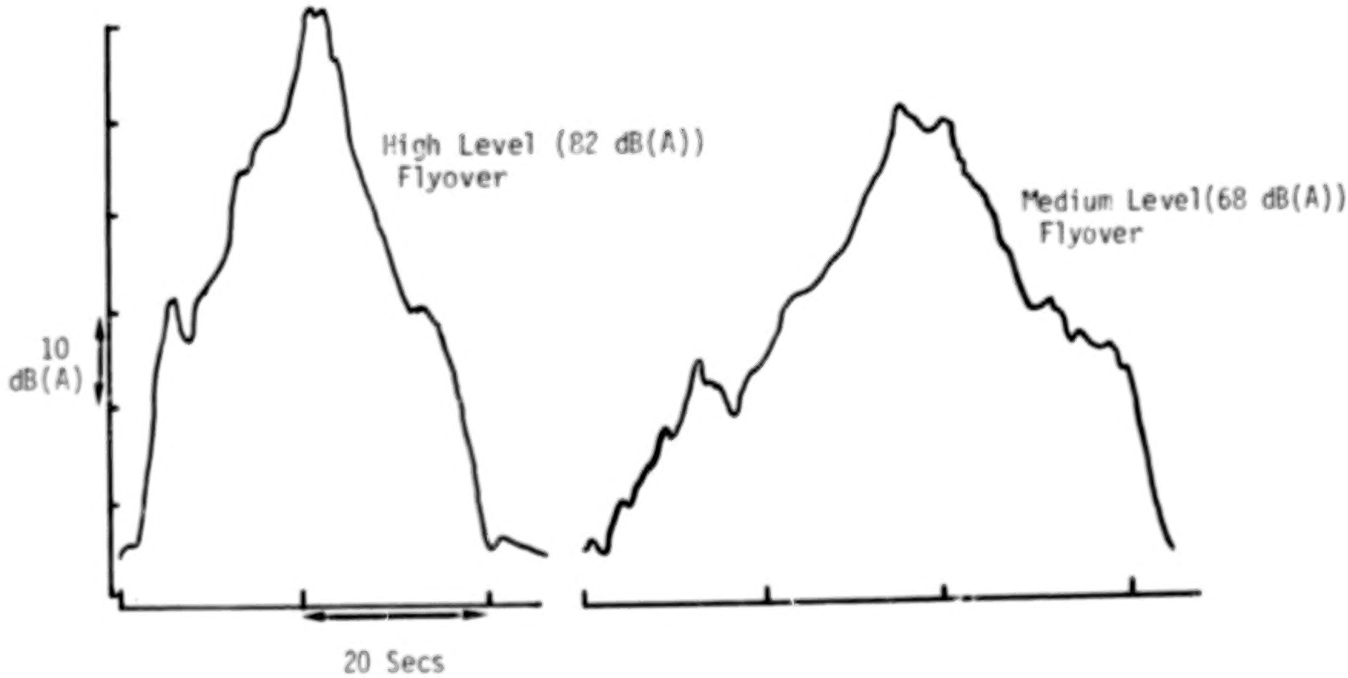


Figure 2.- One-third octave band spectra of test sounds.



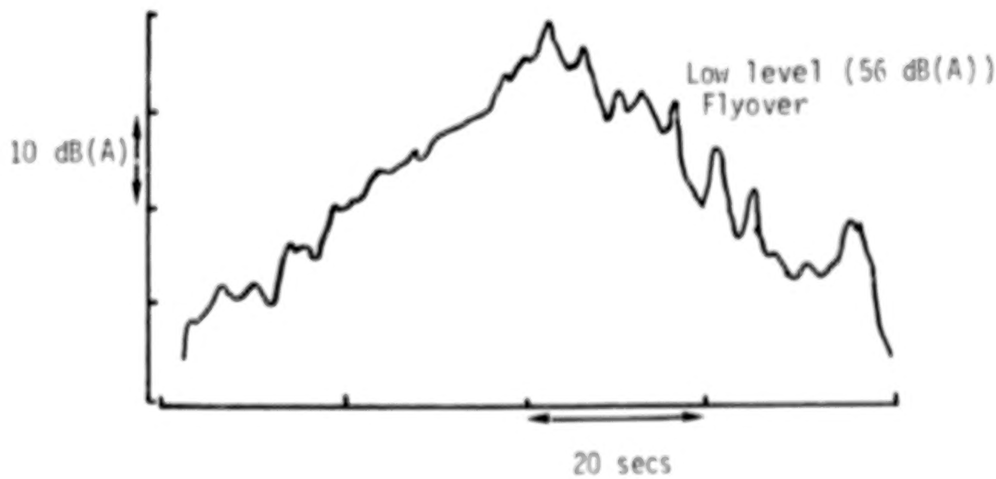


Figure 3. - Time histories of flyovers.

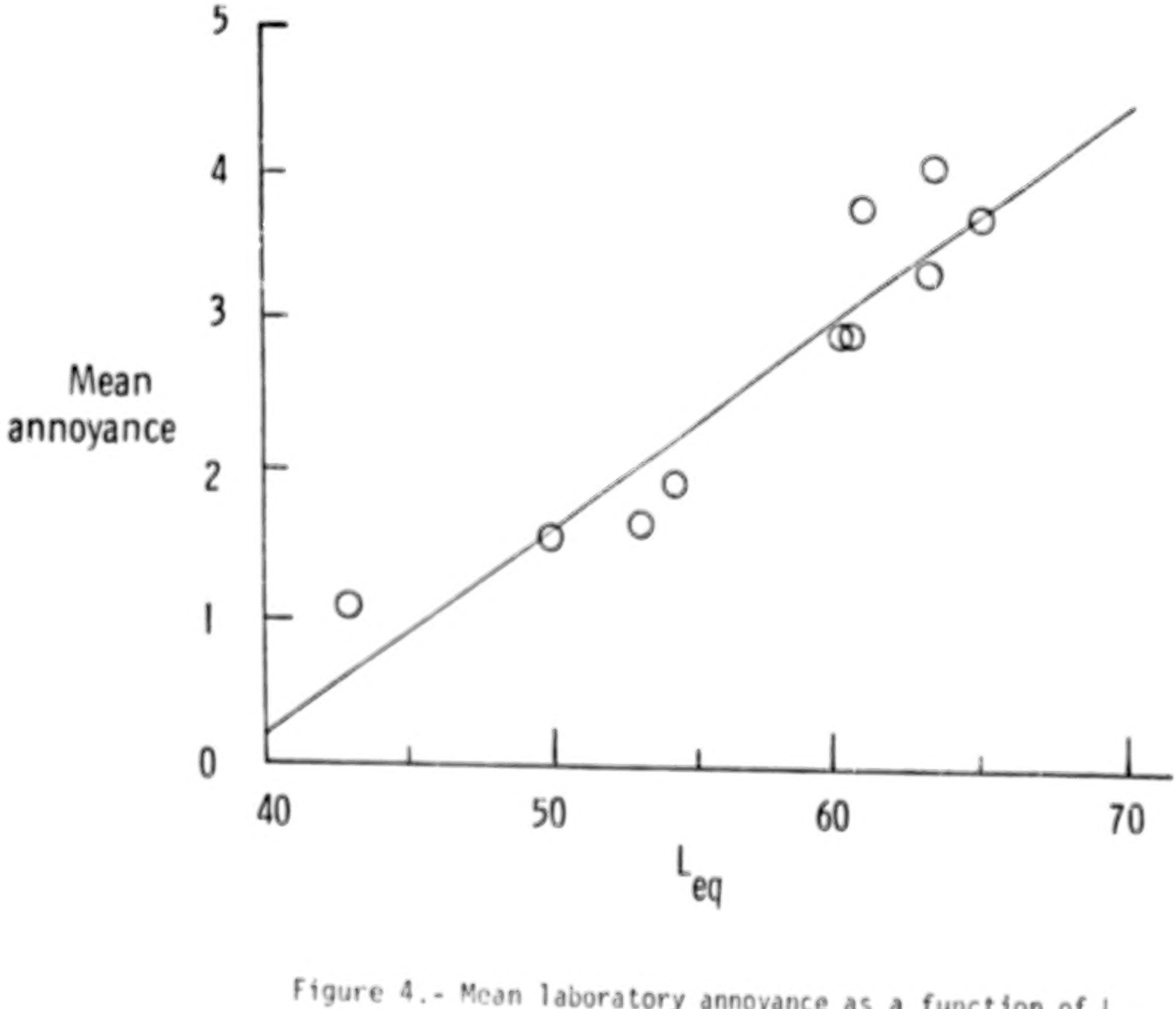


Figure 4.- Mean laboratory annoyance as a function of L_{eq}.

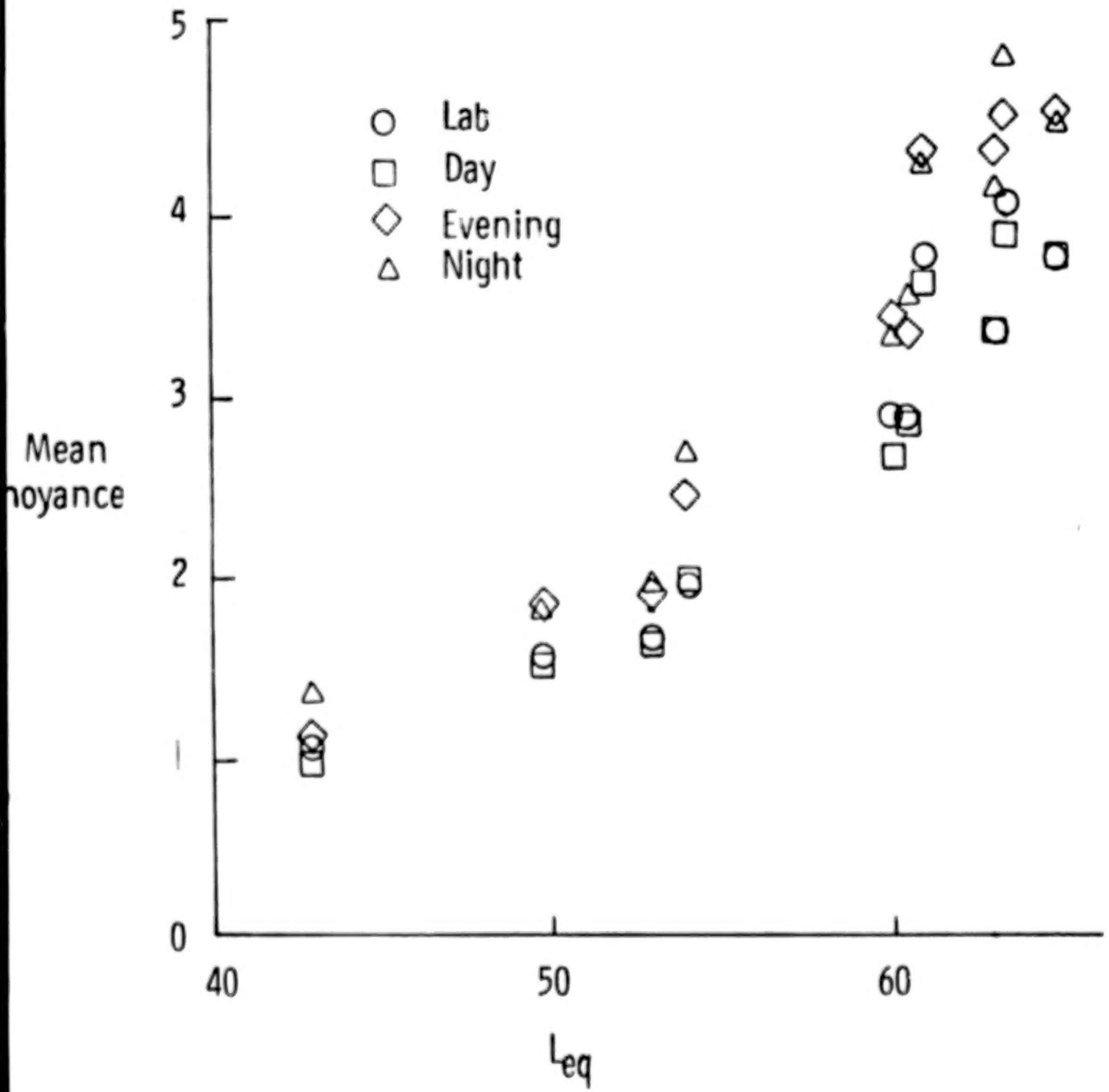


Figure 5.- The relationship between L_{eq} and laboratory annoyance and projected home annoyance.

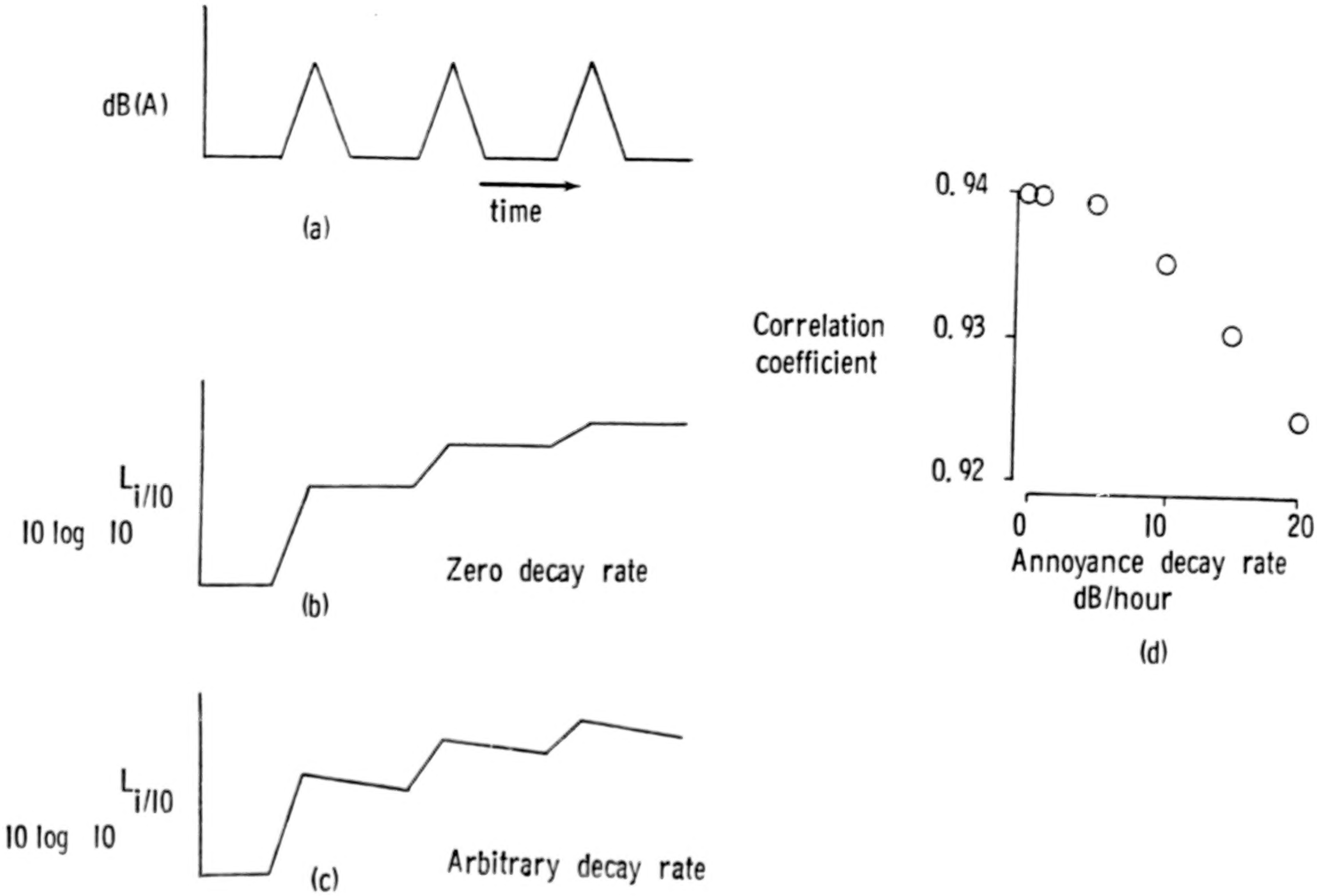


Figure 6.- Annoyance decay hypothesis.

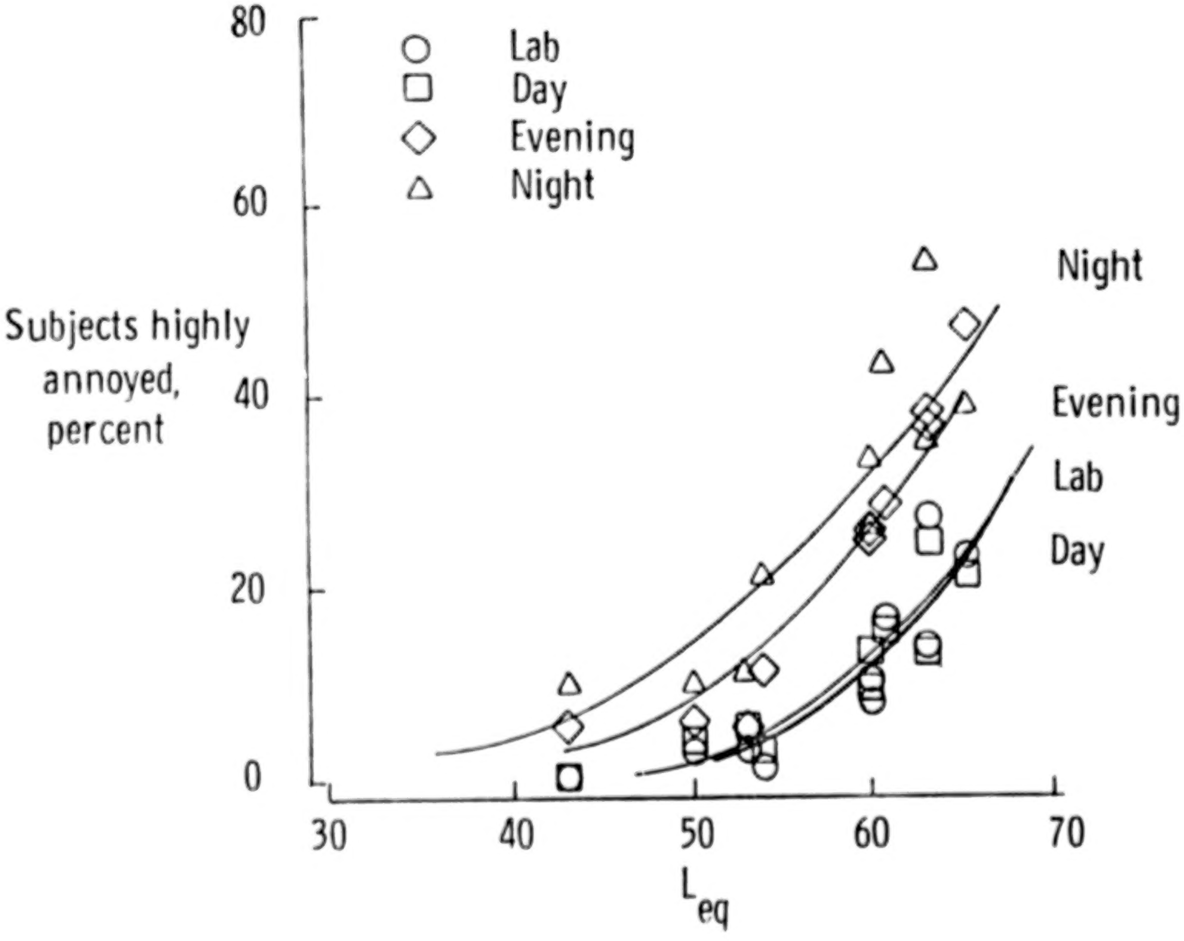


Figure 7.- Percentage of subjects highly annoyed in the laboratory and during the day, evening, and night as a function of L_{eq}.

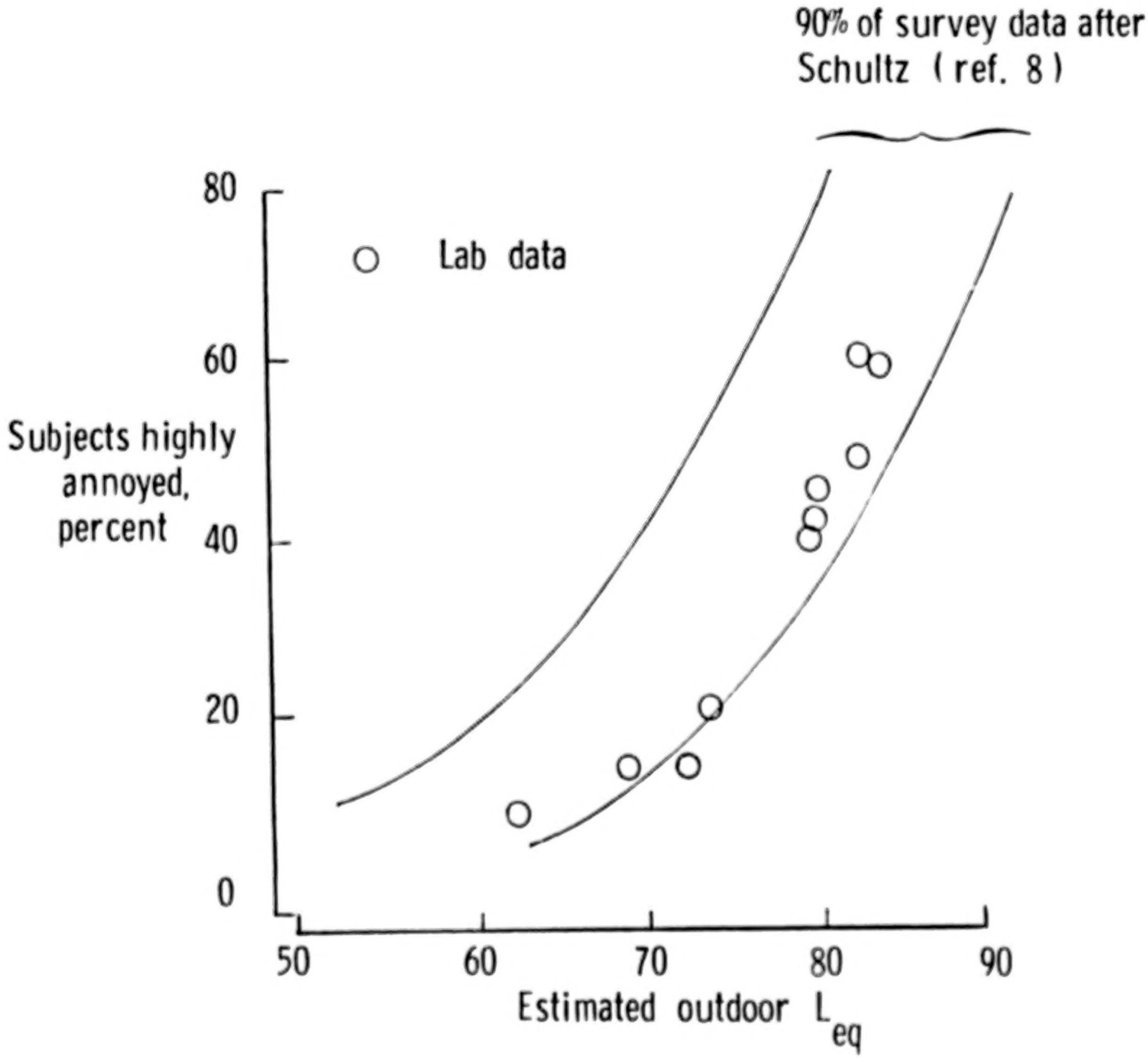


Figure 8.- Percentage of subjects highly annoyed as a function of estimated outdoor L_{eq}.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-3417		

4. Title and Subtitle	5. Report Date
CUMULATIVE ANNOYANCE DUE TO MULTIPLE AIRCRAFT FLYOVERS WITH DIFFERING PEAK NOISE LEVELS	May 1981
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Kevin P. Shepherd	
	10. Work Unit No.
9. Performing Organization Name and Address	
The Bionetics Corporation 18 Research Drive Hampton, Virginia 23666	11. Contract or Grant No. NAS1-14970
	13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code 505-35-13-01

15. Supplementary Notes

Langley Technical Monitor: David G. Stephens
Topical Report

16. Abstract

A laboratory study was conducted in which 160 subjects judged the annoyance of 30-minute sessions of aircraft noise. Each session contained nine flyovers consisting of various combinations of three takeoff recordings of a Boeing 727. The subjects were asked to judge their annoyance in the simulated living room environment of the laboratory and also to assess how annoyed they would be if they heard the noise in their home during the day, evening, and night periods.

The standard deviation of the sound level did not improve the predictive ability of L_{eq}(equivalent continuous sound level) which performed as well or better than other noise measured. Differences were found between the projected home responses for the day, evening, and nighttime periods. Time of day penalties derived from these results showed reasonable agreement with those currently used in community noise indices.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Annoyance Aircraft noise Psychoacoustics	Unclassified - Unlimited Subject Category 45

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	27	A03

For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 19

END

July 29, 1981